Development of a Concentrator with a Rectangular Flat Focus used for Hydrogen Production via Photocatalytic Water Splitting Employing Solar Radiation

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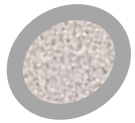
- Summary and Outlook

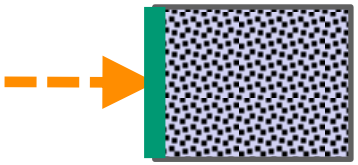
Project HyCats

- Hydrogen production via photocatalytic water splitting

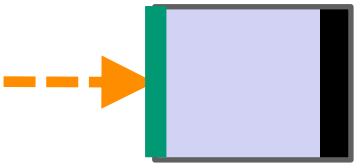
- Design, generation and test of new catalysts
  - Highly efficient and durable
  - Low material costs and long-term availability



- Assessment of new catalysts under concentrated solar radiation



- Suspension

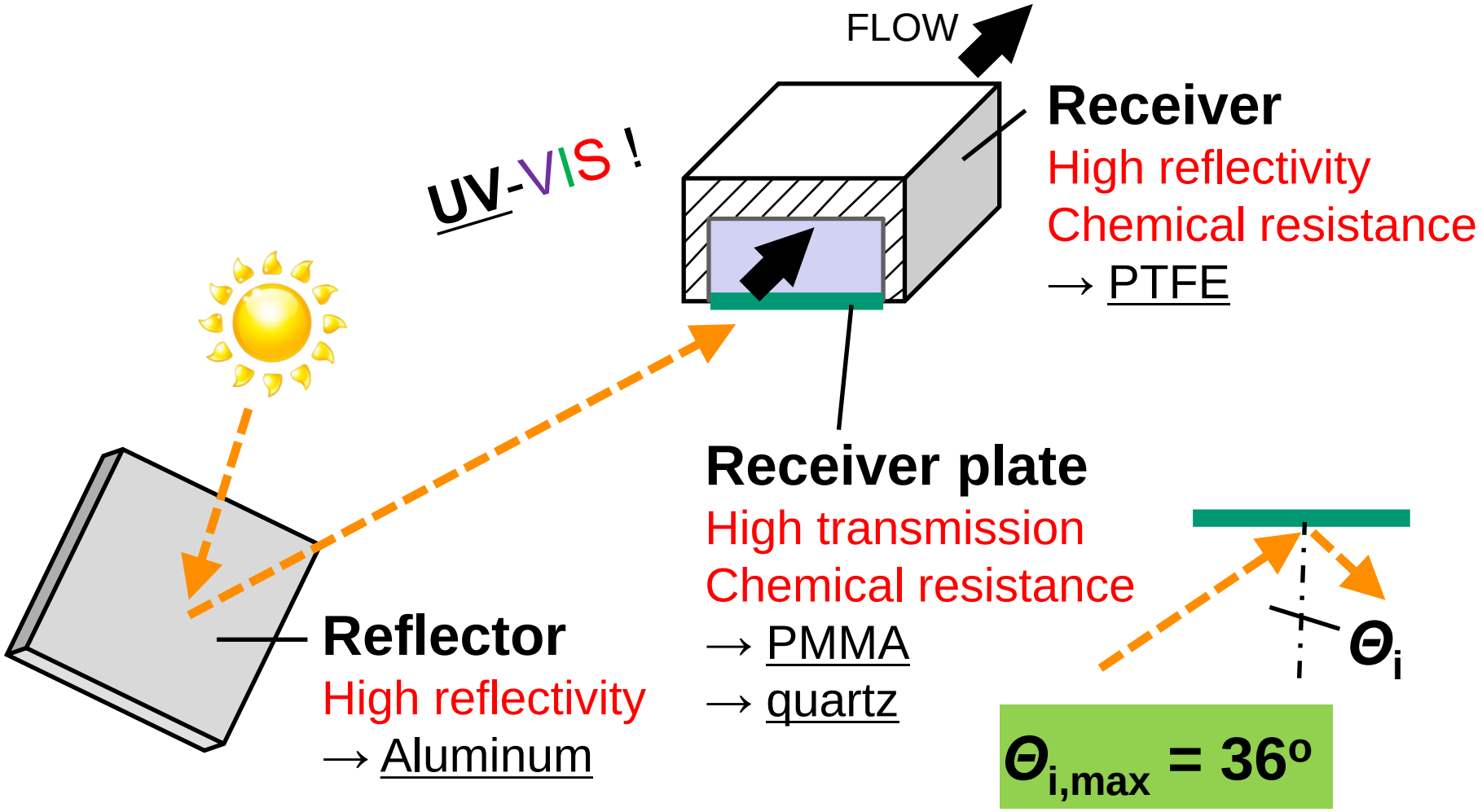


- Flat fixed bed

CONCENTRATOR

- Rectangular focus: 100 mm ≈ 2000 mm
- Concentration: up to 20
- Intensity distribution: homogeneous (< ±5%)
- Tracking: 2-axis (solar azimuth & altitude angle)

Basic Considerations



Choice of a Concentrator Concept

Concentrator

Reflector

Refractor ~~Refractor~~

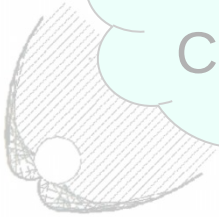
C ≈ 20
Risks
Oblong focus
Complexity / size

Parabolic Trough

Analyzed by ray tracing!

Central Receiver System

Compound Parabolic Concentrator



…

Linear Fresnel Collector

Parabolic Dish

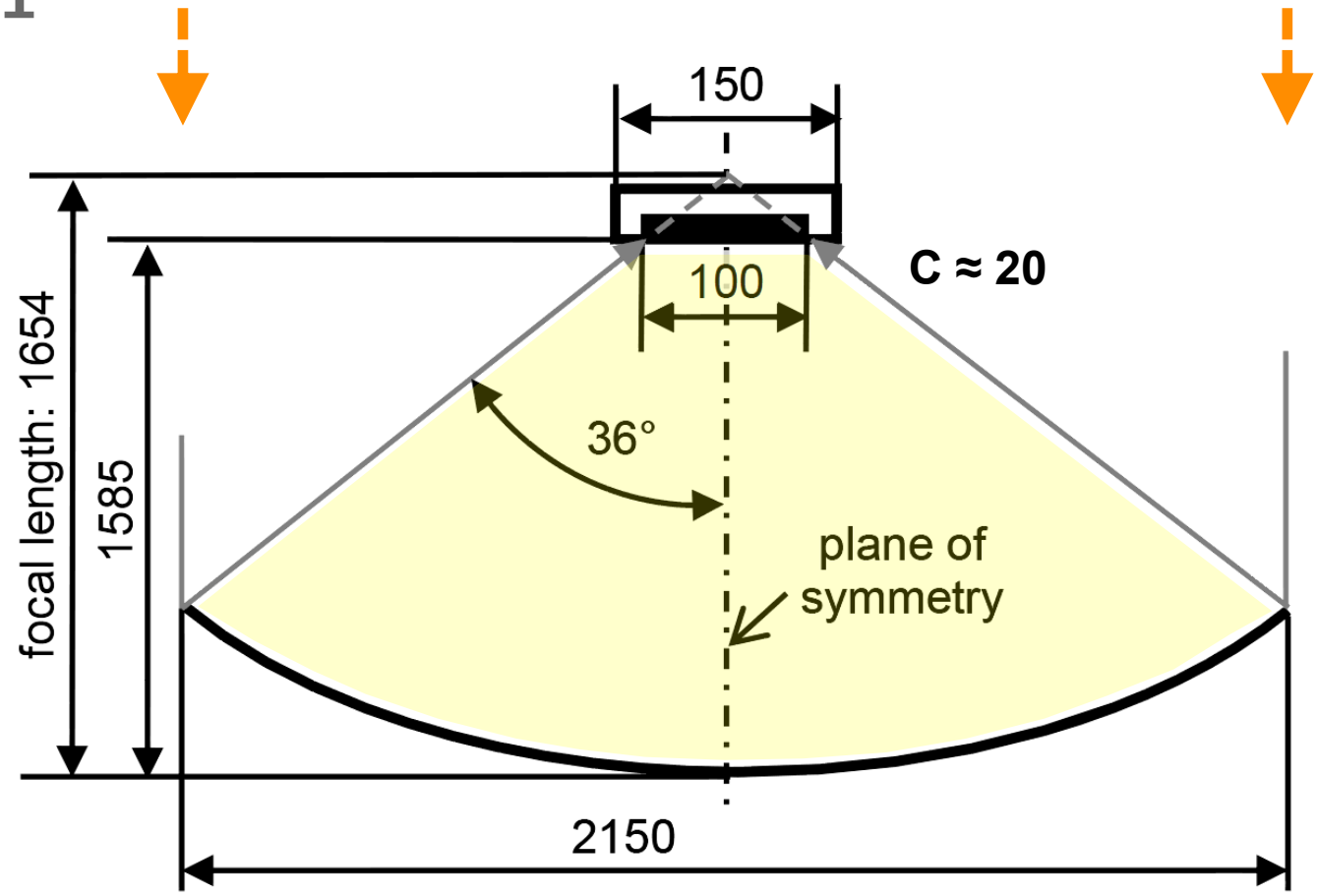
Solar Furnace

DLR

Concept 1

Parabolic Trough

normal incidence (2-axis tracking)



Dimensions in mm!

Concept 2

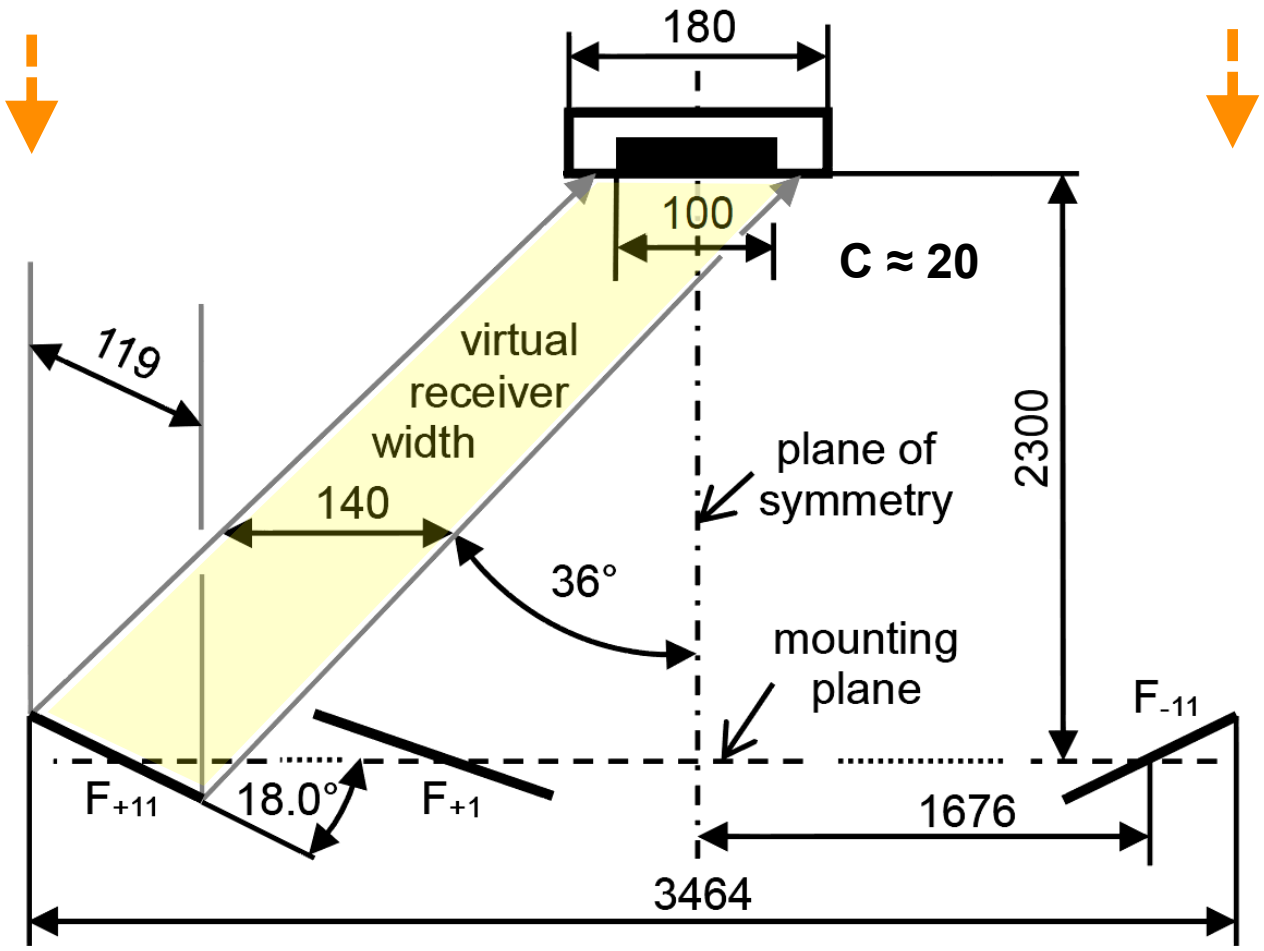
Modified Linear Fresnel Concentrator

Facets:
- moved collectively
- no shading

Width of facets:
119 mm … 139 mm

Angle of facets:
2.932° … 18.037°

normal incidence (2-axis tracking)



Dimensions in mm!

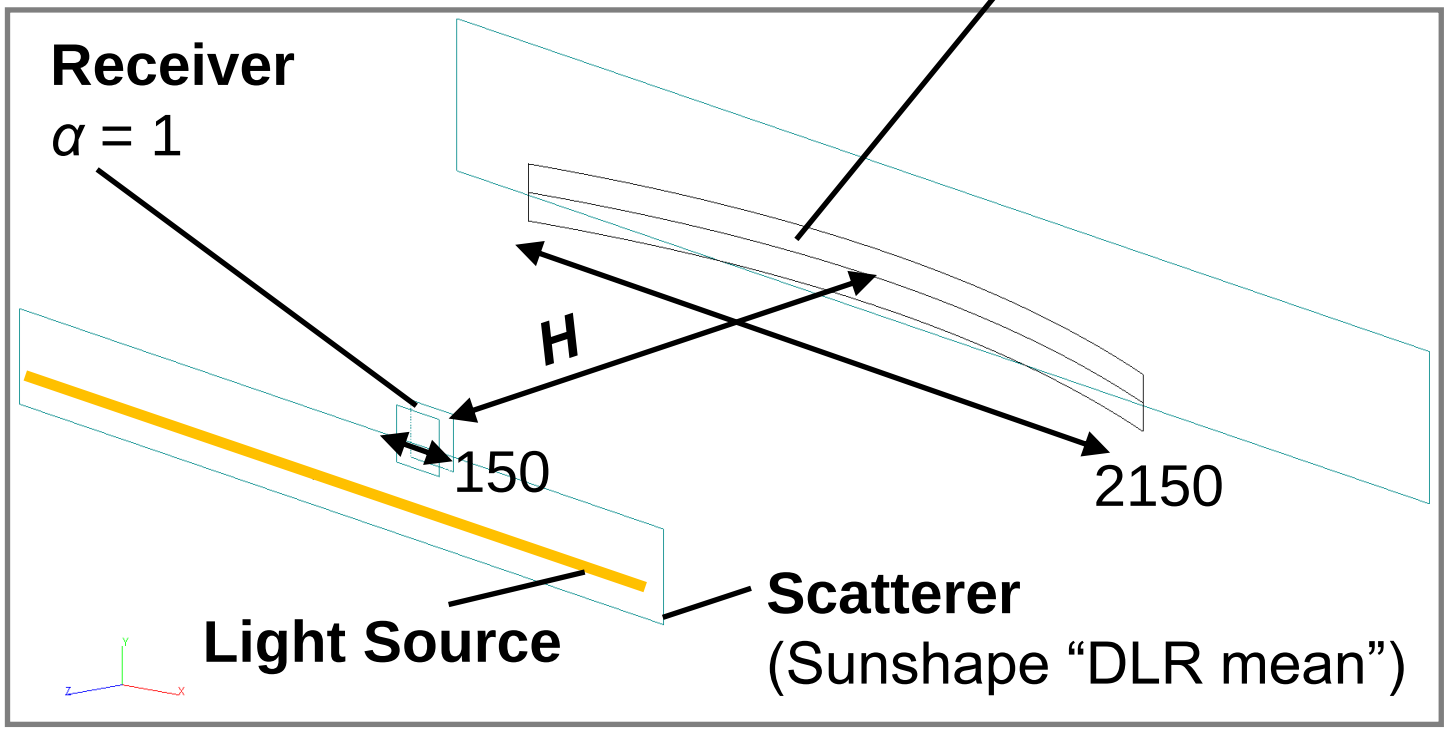
Ray Tracing Model: Parabolic Trough

Parabolic Mirror

$\rho = 1$

$\sigma_{spec} = 1.2$ mrad

Focal length: 1654 mm



H =

(a) 1545

(b) 1565

(c) **1585**

(d) 1605

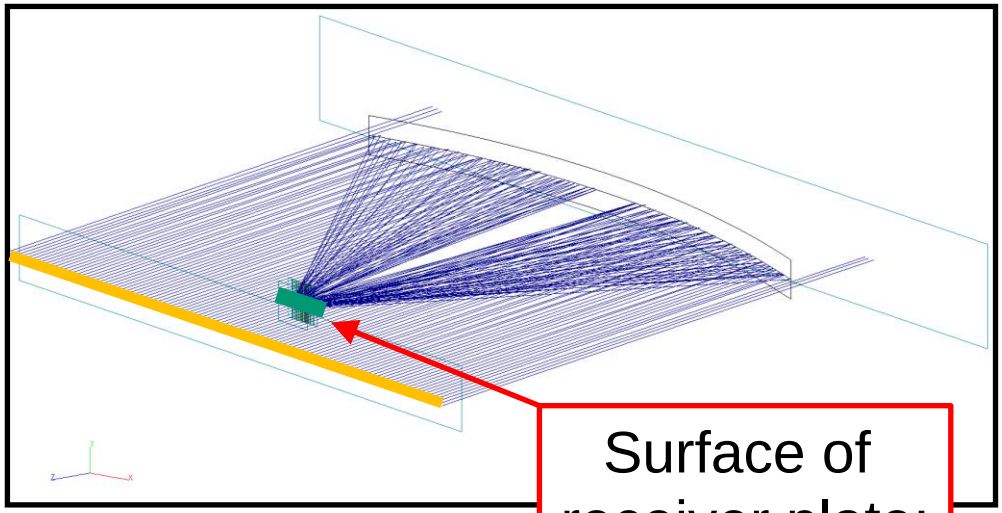
(e) 1625

Dimensions in mm!

OptiCAD Version 10.050

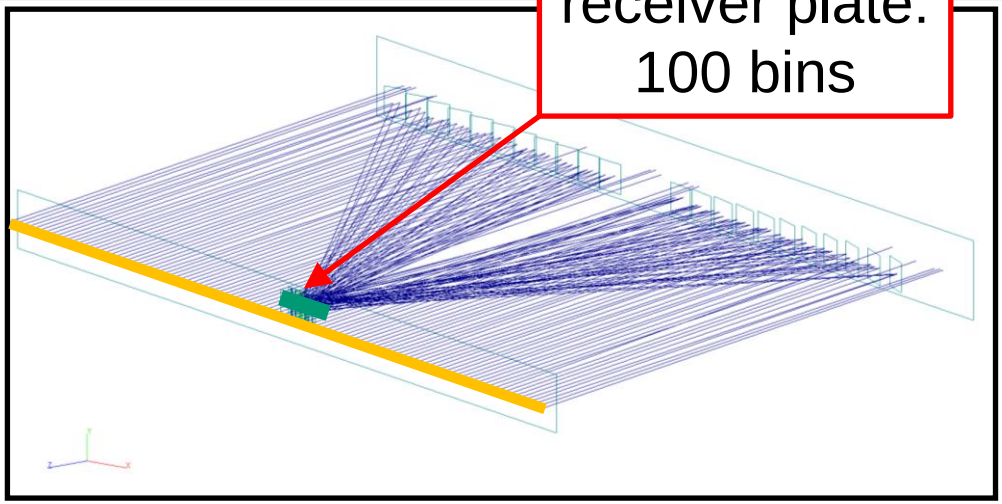
Ray Tracing Illustration: 100 rays

Parabolic Trough



Surface of receiver plate: 100 bins

Modified Linear Fresnel Concentrator



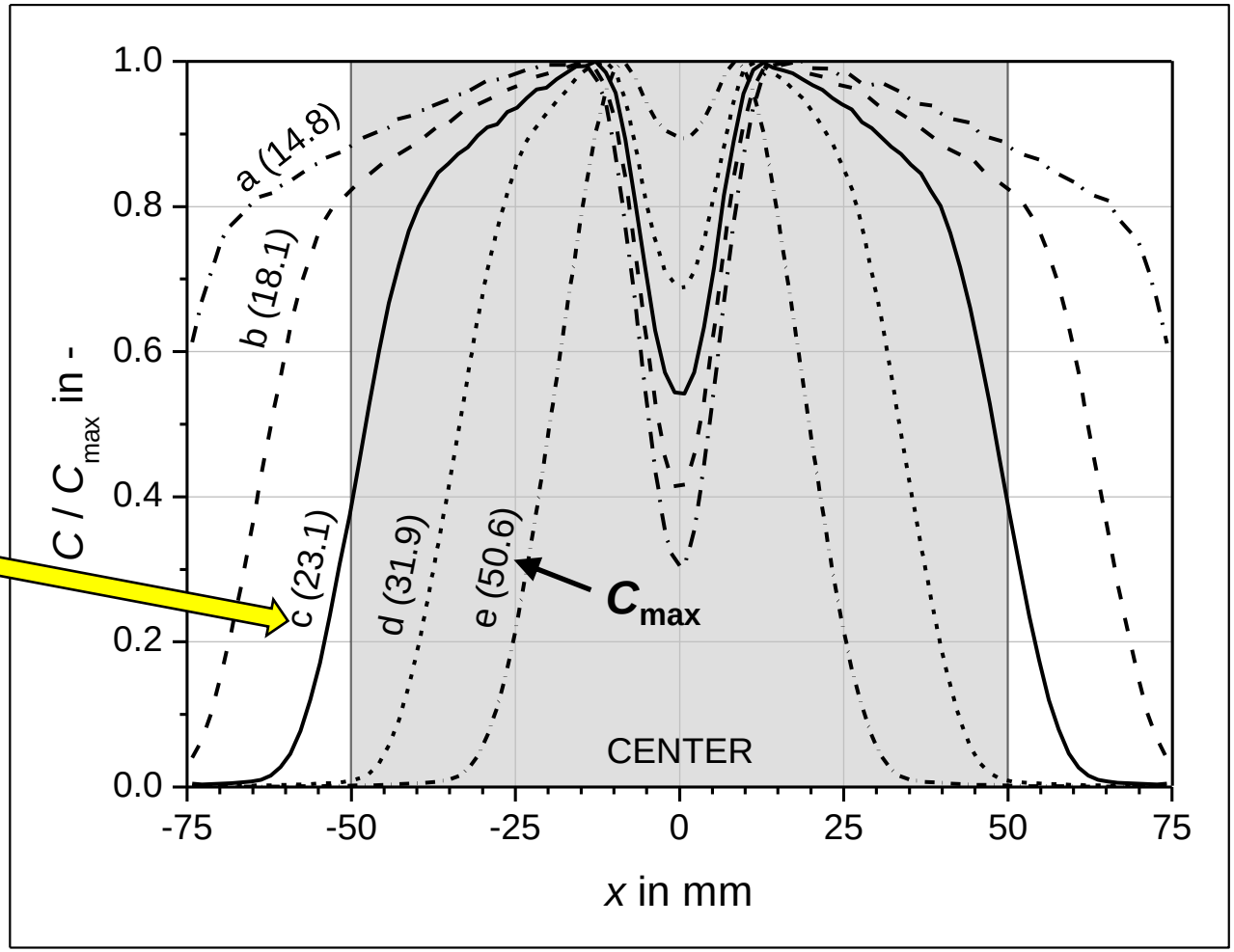
Ray Tracing Results: 10,000,000 rays

No tracking errors!

Parabolic Trough

(a) 1545 mm
(b) 1565 mm
(c) **1585 mm**
(d) 1605 mm
(e) 1625 mm

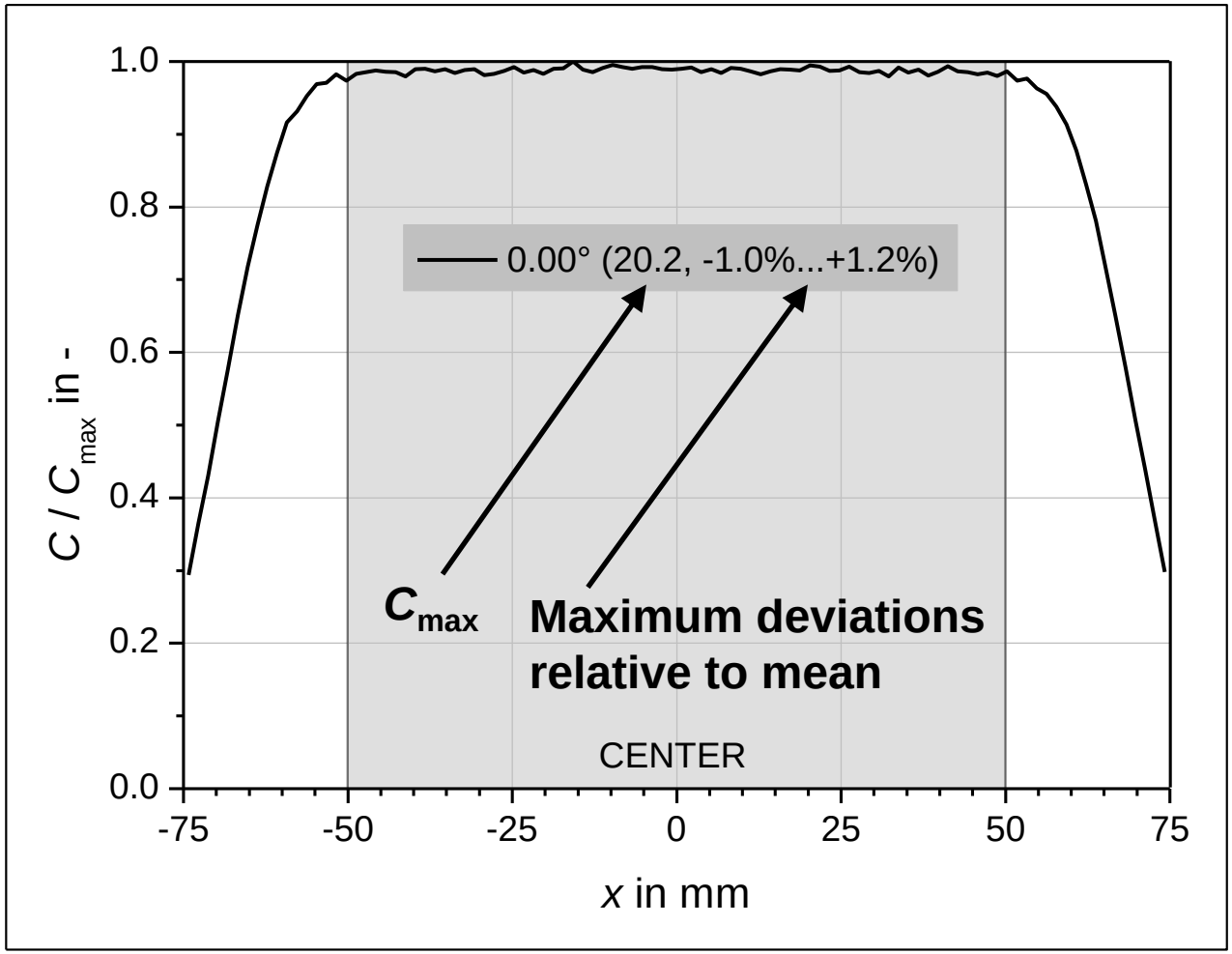
Flat *C*-profile not possible!



Ray Tracing Results: 10,000,000 rays

No tracking errors!

Modified Linear Fresnel Concentrator

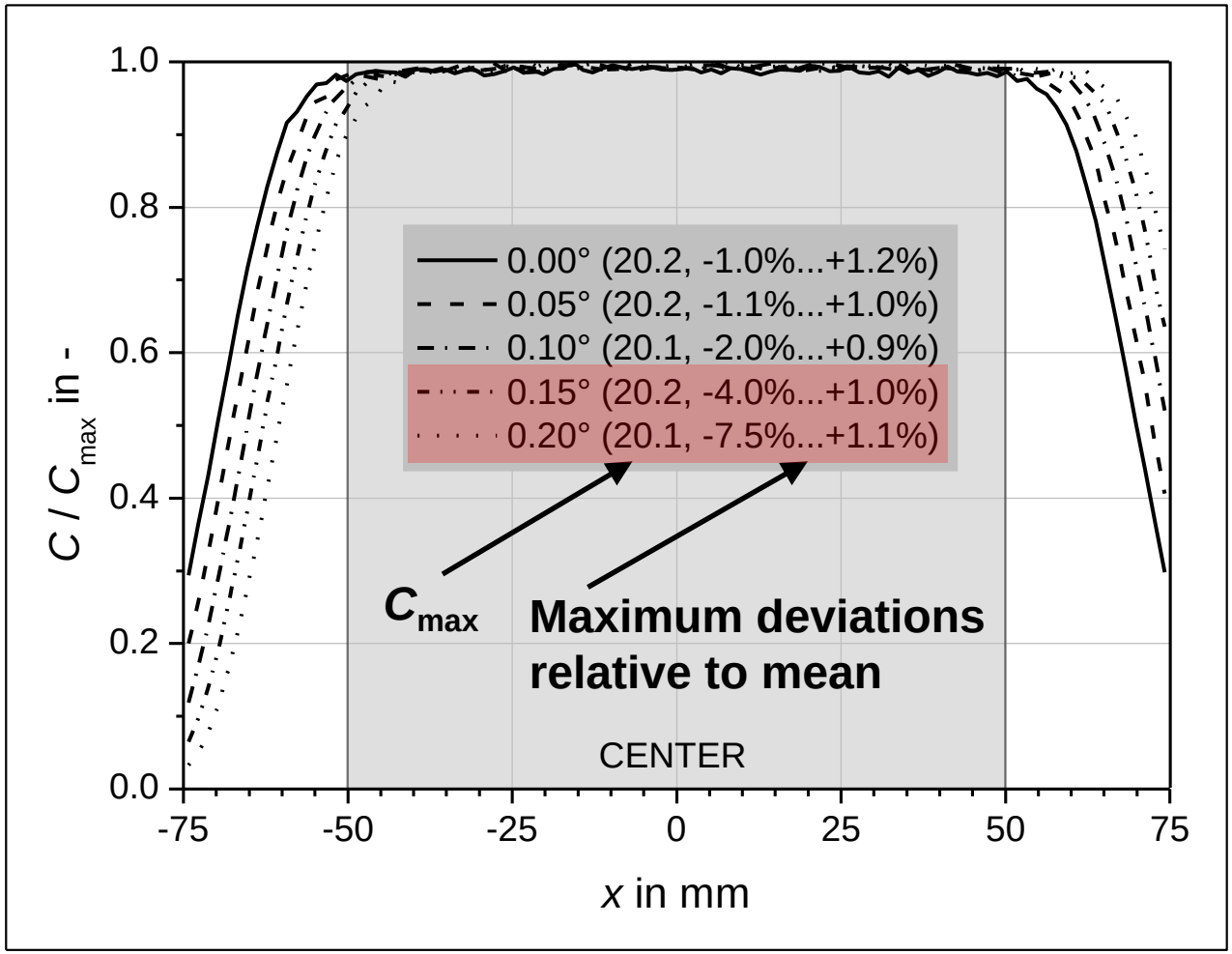


Flat *C*-profile possible!

Ray Tracing Results: 10,000,000 rays

Solar altitude angle tracking error!

Modified Linear Fresnel Concentrator



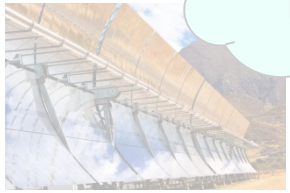
± 0.1° acceptable

Conclusions

$C \approx 20$
Risks
Oblong focus
Complexity / size
Flat focus

Modified
Linear
Fresnel
Concentrator

Parabolic
Trough



± 0.2°

< ± 1%

Improved

Fields of improvement

- Adapted virtual receiver widths
- Reduced number of different facets

DLR

Summary

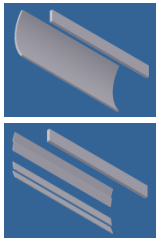
- Hydrogen Production via Photocatalytic Water Splitting

- Concentrator with rectangular flat focus

C ≈ 20 100 mm

≈ 2000 mm

- Concepts analyzed by ray tracing:



1) Parabolic trough

2) Modified linear Fresnel system

- Improved design with

1) homogeneous distribution of radiation

± 0.2°

< ± 1%

2) only one facet width

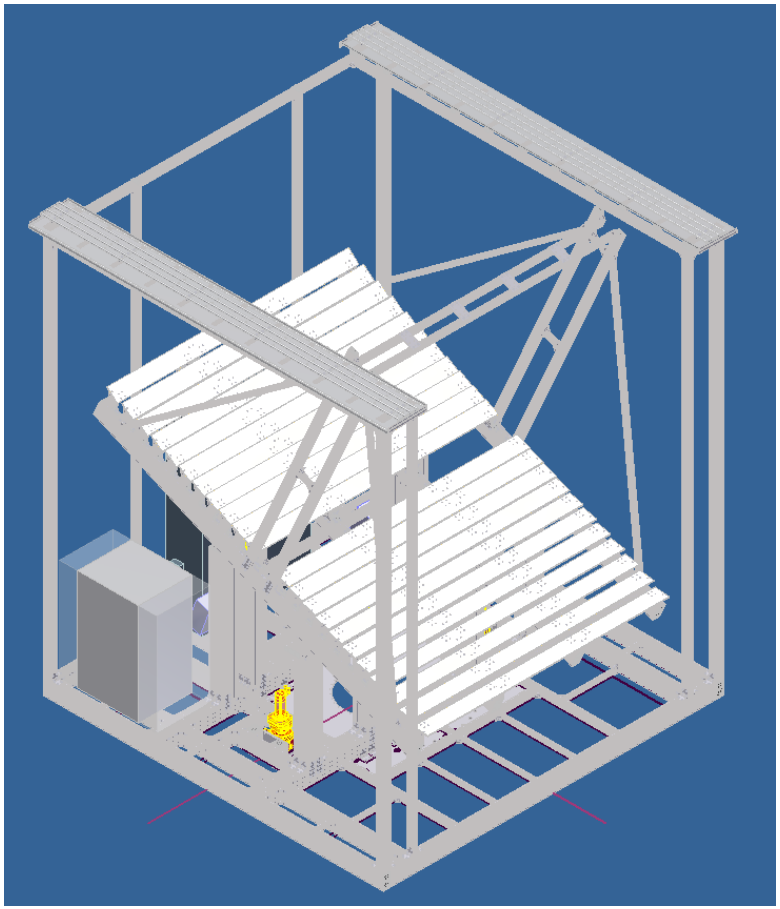
Outlook

- Improved design under construction

- Integration in high performance test facility for experiments in the field of photocatalytic water splitting

- Further applications:
  - water treatment
  - photovoltaic cells
  - …

Source: BMU

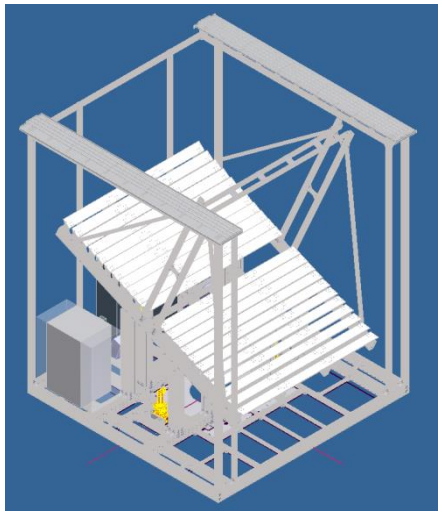


Thank you for your attention!

Acknowledgements

- Dr. Björn Schiricke (DLR)

- HyCats (01RC1012E)



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